覆晶封裝銲錫接點在介面反應，電遷移與熱遷移下之顯微結構變化

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摘　要

覆晶 (Flip Chip)接合封裝技術中，一個銲錫凸塊往往包含不同的金屬化墊層(Under Bump Metallization, UBM)結構。而銲錫接點與金屬墊層的反應則直接會影響到接到的機械性質以及電性。同時隨著無鉛銲錫的採用，與銲錫反應較為和緩的Ni金屬墊層也逐漸成為關注的焦點。

本論文第二章，探討了電鍍Ni與無電鍍Ni與銲錫接點的迴銲以及時效之反應．由於電鍍Ni為結晶結構，而無電鍍Ni雖為非晶質結構，卻會在反應之過程中形成一層柱狀之Ni_3P，而相對的加快了反應之速度。而由其兩種金屬墊層與錫鉛以及無鉛銲錫之反應，可以明確得到電鍍Ni確實大大的減緩了介面反應的速率，相對降低界金屬化合物Spalling的可能性。

同時，隨著可攜式電子產品微小化的趨勢，覆晶封裝銲錫接點也

須隨之縮小，因此銲錫接點所承載的電流密度逐漸提高，在高電流密度的影響下，覆晶封裝銲錫接點因電遷移產生可靠度的議題受到重視。此外，導線所產生的焦耳熱效應嚴重影響銲錫接點內部的溫度分布，因為溫度差產生的溫度梯度產生熱遷移的破壞，熱遷移的破壞也越來越受到注目。

後續的三四章，討論電遷移對於銲錫接點的影響。除了利用Kelvin Four-point Probe監控銲錫接點之電阻在電遷移測試中的變化外，同時也觀測相對應的微觀結構變化。而為了可以更加準確的預測出銲錫接點之壽命，利用鋁導線TCR之特性，我們可以成功校正得到銲錫接點在測試中的真實溫度，有助於正確的估算出電遷移之活化能。不同金屬墊層材料及設計對於接點壽命的影響，相較於Cu UBM，Ni UBM則據有較高的抗電遷移以及熱遷移之特性因而有較長的接點壽命。

第五與第六章，針對越來越受到矚目的熱遷移現象做較深入的討論。與以往觀察到的不同，上方的Cu金屬墊層，除了會因為具有往冷端移動的特性外，更因為在Sn-based為主的銲錫接點中可沿著c軸進行非常快速的間隙型擴散，導致在沒有電流通過的和錫接點下中也會有相當嚴重程度的破壞。反之，Ni金屬並無出現同樣的破壞機制。

同時，另一意外的發現為：在沒有通過電流的銲錫接點上方之鋁導線也有嚴重的破壞產生。穿透式電子顯微鏡之分析，顯示為擴散阻

障層之Ti也消失不見，故我們推論不僅僅是Al本身之熱遷移，連同Ti之熱遷移，才會造成導線之破壞。

Microstructure Changes Associated with Interfacial Reactions, Electromigration and Thermomigration in Flip Chip Solder Joints

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Abstract

It has been reported that the choice of proper under bump metallization (UBM) plays an important role in determining the reliability of solder joints. Ni, compared with Cu, possesses slower reaction rate with Sn-based solder joint and lower solubility therefore has been studied recently. Here in chapter 2, we analyze the interfacial reaction between solder and electroplated Ni and eletroless Ni for the reflow and aging reaction at the same time with SnAg and SnPb solder joints. Electroless Ni has much faster reaction rate instead of Electroplated Ni due to the transformation of amorphous phase to a Ni_3P crystalline phase.

The carry-on current density in the solder joint needs to be increased to 10^4 A/cm^2 or higher due to the shrinking of portable devices. Under such high current density, the electromigration and the companied thermomigrtion in the solder joints becomes a serious reliability issue. To predict a more accurate mean time to failure, the Black's equation needs to modify by calibrating the true test temperature and therefore the eletromigration activation energy, which both these two can have great influence on prediction. By utilizing Kelvin four-point probes, a criteria of 20% resistance increase is established and the microstructure change has been analyzed as well. With the temperature calibration by using Al TCR effect, up to 10% discrepancy in activation energy can be reached.

For thermomigration, unexpected void formation was observed in powered and unpowered bumps. Besides Sn thermomigration itself, we proposed a model of thermomigration of Cu-Sn IMC to explain. The fast interstitial diffusion of Cu inside Sn matrix combined with the tendency of thermal migrate to cold end of Cu, damage appeared at those bumps even with current stressing. For further investigation, void formation inside Al trace and the disappearance of Ti layer was found surprisingly. According to literatures, Al has the tendency to cold end, and so is Ti, which possesses a much larger heat of transport. More details will be discussed later in chapter 5 and 6.

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